

## SOME TRENDS IN WOOD ADHESIVES FOR LOW OR NO FORMALDEHYDE EMISSION

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### UFs of LOW FORMALDEHYDE EMISSION

- Not a yet a Problem in Europe, BUT
- JAPAN F\*\*\*\* standard is far more severe
- If JAPAN's F\*\*\*\* spreads to other countries are there ways to satisfy easily the standards, or better? :
- the answer is YES, with a variety of different technologies, new and/or old.

### Technologies to decrease/eliminate formaldehyde content and emission

- Phenol-formaldehyde (PF) and phenol-urea-formaldehyde (PUF) resins
- UF/isocyanate, MUF/isocyanate, PF/isocyanate
- MUF resins of low formaldehyde content
- Tannin adhesives without formaldehyde
- isocyanates
- M, U and MU resins with non-toxic, non volatile aldehyde.
- New Entries

**MOST OF THESE RESINS  
ALREADY EXIST  
AND  
ARE ALREADY USED  
INDUSTRIALLY TO-DAY**

## AND UF RESINS?

- UF resins of formaldehyde emission low enough to satisfy F\*\*\*\* can be produced. It seems one major adhesive manufacturer already produces them for the Japanese market
- But they are more expensive and higher amounts used
- And Japanese standard intends tightening further formaldehyde emission regulation: towards an effective formaldehyde emission ban? (note, not a ban of formaldehyde).

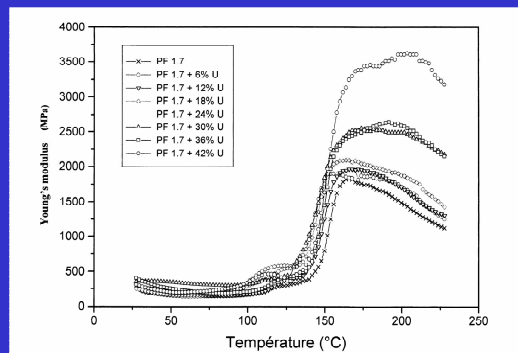
## IF JAPAN'S F\*\*\*\* TAKES HOLD

- ONLY PF RESINS, PUF, hybrid PF/MDI, UF/MDI resins, top range MUF resins and Tannin adhesives WILL SURVIVE SHORT TO MEDIUM TERM
- NEW RESINS AND TECHNOLOGIES WILL PENETRATE MORE DEEPLY THE MARKET. AMONG THEM, BUT NOT ONLY, NATURAL ADHESIVES AND SOME OF THE ABOVE
- ISOCYANATES ALONE MIGHT HAVE EVENTUALLY THE SAME POLLUTION PROBLEMS OF FORMALDEHYDE

## FAST-CURING PF RESINS

- To-day as fast pressing as UF and MUF by
- 1. use of ester accelerators
- 2. alkaline setting PUF resins
- 3. alkaline setting PF/MDI hybrid resins
- Extremely low emission as these resins are completely stable

## FAST-CURING PF RESINS

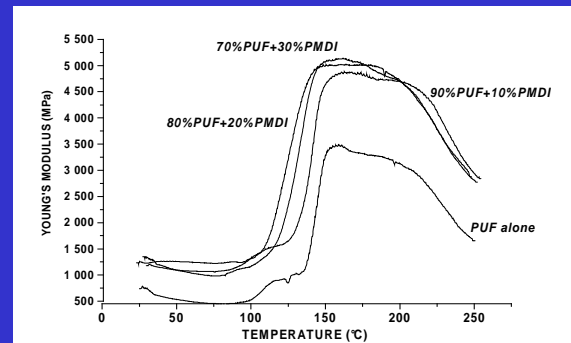


### HYBRID ISOCYANATE RESINS

by DECREASE/ELIMINATION OF  
TOXIC  
-NCO GROUPS IN ISOCYANATES

- BY CO-REACTION OF ISOCYANATES  
WITH TRADITIONAL WATER-BORN  
ADHESIVES

### PF/pMDI, PUF/pMDI, UF/pMDI



### Melamine and Urea resins without any formaldehyde

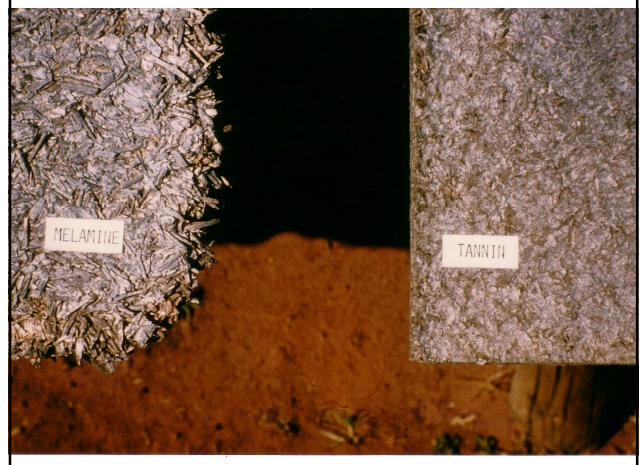
- A major chemical group has developed M and U formulations based on a non-toxic, non-volatile aldehyde.
- Press time is still slower but will be improved
- This aldehyde is still relatively expensive, but if industrial demand increases dramatic shifts in prices will result

### SHIFT TO NATURAL ADHESIVES

- Tannin Adhesives NEW TECHNOLOGIES (not the old ones)
- Protein Adhesives
- Carbohydrate Adhesives
- Unsaturated Oils Adhesives
- Hybrid glyoxylated lignin adhesives

## TANNIN ADHESIVES

1. IMPROVEMENT OF TRADITIONAL SYSTEMS
2. NEW HARDENERS
3. AUTOCONDENSATION

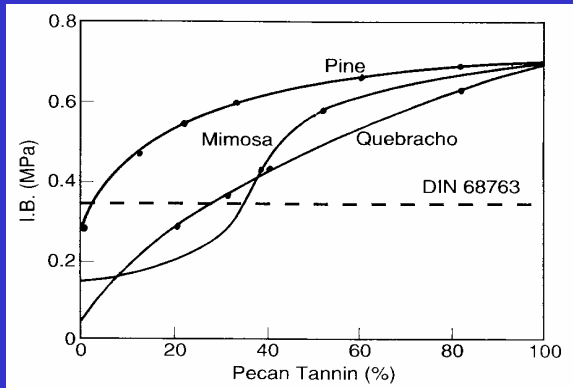
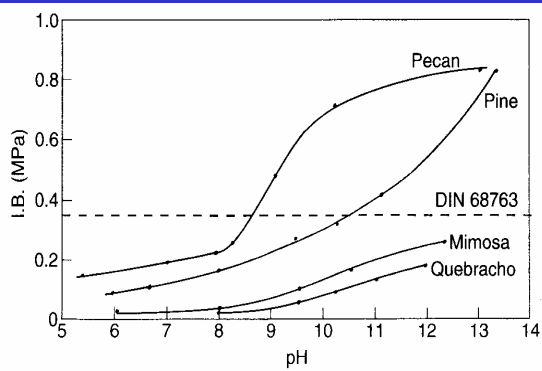


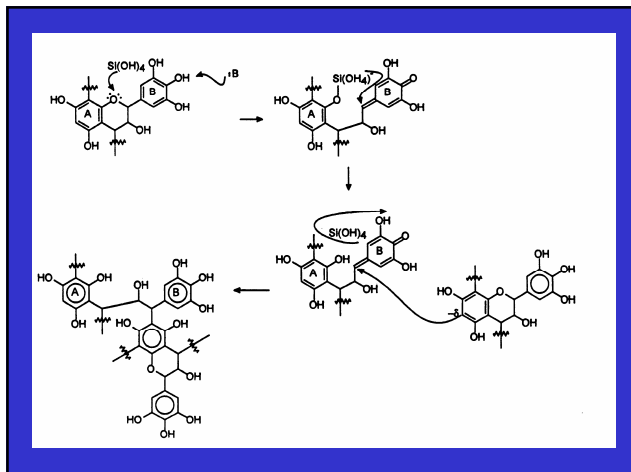
2005-2006 Japanese Use of Tannins:  
EFFECTIVE EMISSION = 0.0



BONDING BY TANNINS  
AUTOCONDENSATION

ENVIRONMENT FRIENDLY GLUING  
WITHOUT ANY ALDEHYDE



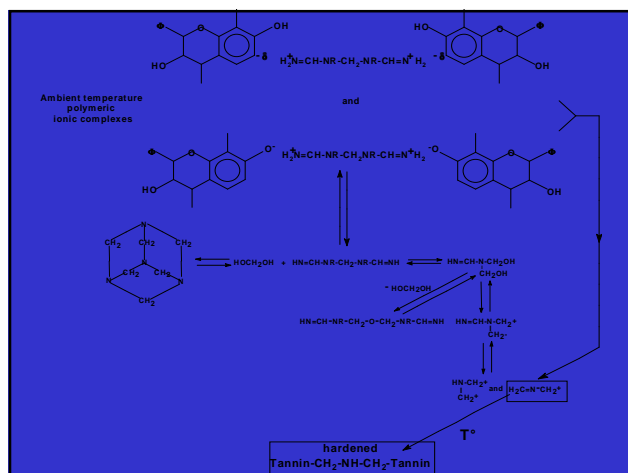


## ALTERNATIVE HARDENERS

- Methylolated Nitroparaffins, i.e. Trishydroxymethyl nitromethane
- glyoxal
- Hexamethylenetetramine (HEXAMINE)

IN PRESENCE OF FAST-REACTING COMPOUNDS HEXAMINE IS NOT A FORMALDEHYDE-YIELDING COMPOUND

- In presence of MELAMINE
- In presence of RESORCINOL
- In presence of TANNINS



## PROTEIN ADHESIVE (SOY)

Properties of soy-PF40 and commercial PF random strand laboratory panels\*

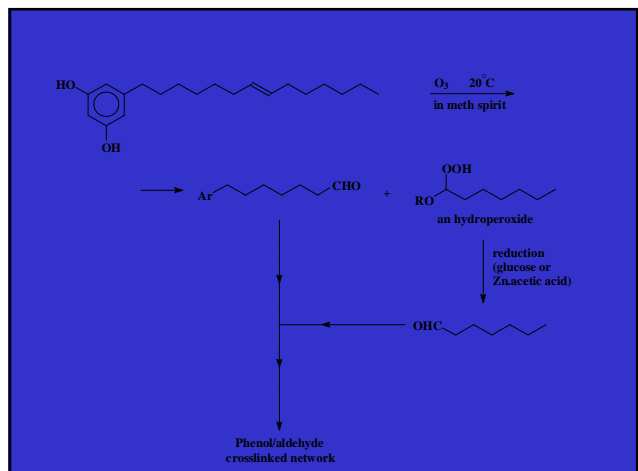
Face resin	Density (kg/m <sup>3</sup> )	Thickness swell (%)				Internal bond (MPa)	
		2-h Boil		24-h Cold water		Dry	Wet
PF control	677	62.8	(4.8)	15.2	(1.5)	0.60	0.06
Soy-PF40	696	65.1	(3.6)	14.5	(1.7)	0.62	0.06

## CARBOHYDRATE ADHESIVES

- As modifiers of existing PF and UF adhesives
- By forming degradation compounds that can be used to form resins for adhesives: i.e. FURANIC RESINS (but furanic monomers are toxic)
- Directly as wood Adhesives: i.e. Liquefied Wood (phenol present)

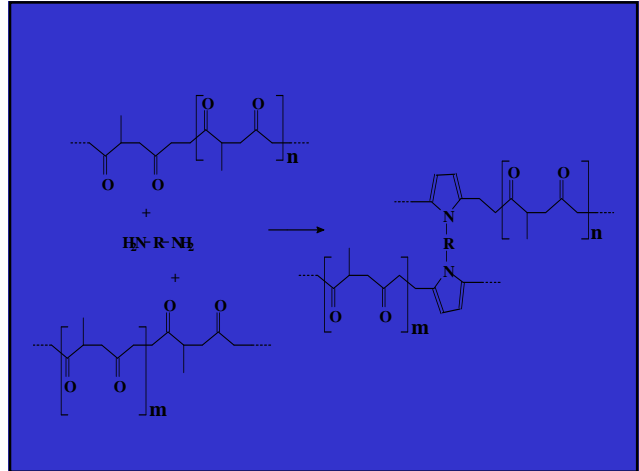
## UNSATURATED OILS

- Epoxidized unsaturated oils: acceptable results for panels but pressing times are far too long. They are relatively expensive
- Cashew nut shell liquid



## Hybrid Glyoxylated Lignin Adhesives

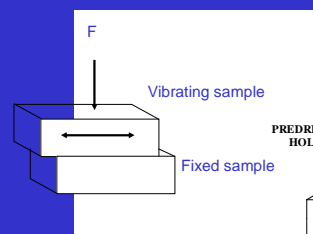
- Non-traditional technology
- Must watch out not to be drawn in traditional lignin/PF resins
- Hybrid MDI/PF/glyoxylated lignin and MDI.glyoxylated lignin adhesives, with lignin up to 65% of total
- glyoxal is classified as non toxic (LD50 > 7000 mg /kg) and non-volatile
- Pressing times industrially significant



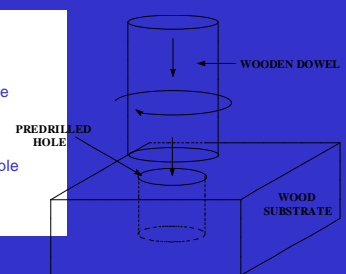
## WOOD WELDING WITHOUT ADHESIVES



### 1. Vibrational



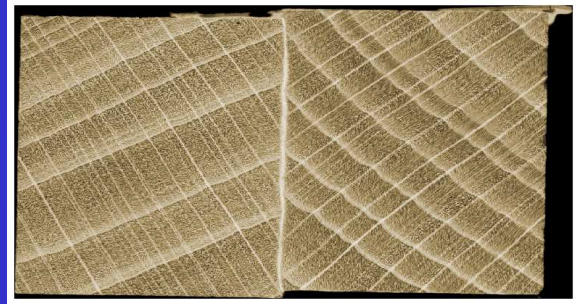
### 2. Dowel rotation





### RESULTS - PARAMETERS

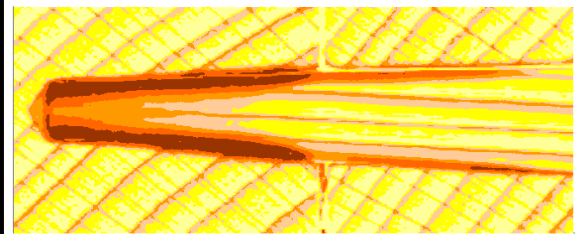
Welding Time (s)	Welding Pressure (MPa)	Holding Time (s)	Holding Pressure (MPa)	Water spray (g/min)	Number of specimens tested	Tensile Strength (MPa)
3	1.5	2	1.5	No	10	3.84 ± 1.3
3	1.5	2	2	No	10	2.26 ± 1.8
3	1.5	5	1.5	No	10	9.40 ± 1.2
3	1.5	5	2	No	10	10.45 ± 0.9
3	1.5	5	2	yes	10	10.37 ± 1.0
4	1.5	2	1.5	No	10	1.18 ± 0.4
4	1.5	2	2	No	10	0.86 ± 0.2
4	1.5	5	1.5	No	10	8.79 ± 0.8
4	1.5	5	2	No	10	6.41 ± 1.2
4	1.5	5	2	yes	10	8.47 ± 0.8
5	1.5	2	1.5	No	10	0.82 ± 0.3
5	1.5	2	2	No	10	0.51 ± 0.2
5	1.5	5	1.5	No	10	7.54 ± 0.8
5	1.5	5	2	No	10	4.55 ± 1.3
5	1.5	5	2	yes	10	4.44 ± 1.2



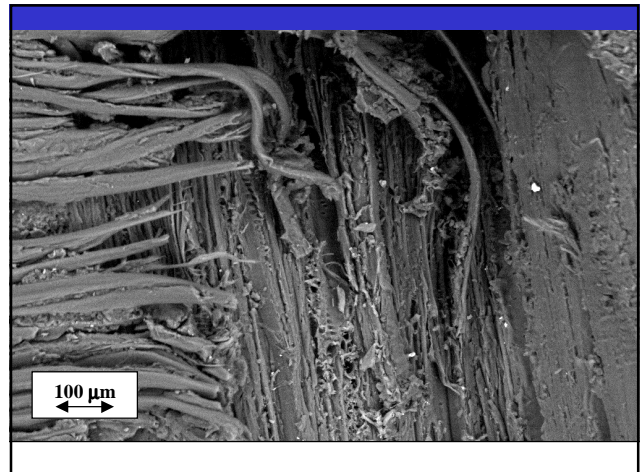
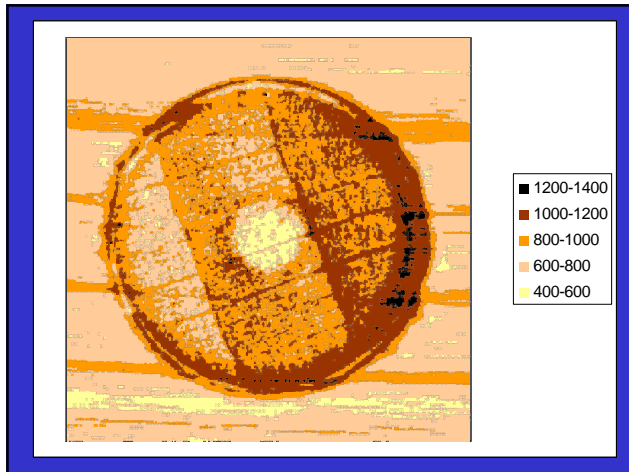
### BUT ONLY FOR JOINING

- Solid Wood to Solid Wood
- Solid Wood to Wood Panel
- Wood panel to Wood Panel
- CANNOT BE USED FOR BOARDS

### Dowel Welding



kg/m<sup>3</sup> 550-700 700-850 850-1000 1000-1150 1150-1300 1300-1450



### Dowel Welding

Test	Grain direction	Wood species	Dowel type	Hole diameter (mm)	Rotation rate (rpm)	Insertion time & holding time	Average tensile strength (N)
Welding Best combination	T+R	Beech	Fluted groove	9	1200	400mm/min	> 2124*
PVA control	T+R	Beech	Fluted groove	10	0	24 hours	> 3180

\* dowel shaft breaks outside welded area in all cases. R = radial section. T = tangential section

- ### Conclusions
- Accelerated PFs, PUFs resins
  - Mixed PF/pMDI, UF/pMDI, PUF/pMDI
  - Top of the range MUFs
  - M and U resins with other aldehyde
  - New adhesives, as yet unknown
  - Wood Welding without adhesives
  - Natural adhesives
    - tannin autocondensation
    - hexamine (for synthetic adh. too), and other hardeners
    - protein adhesives
    - carbohydrate adhesives
    - Unsaturated oil adhesives

THANK YOU

FOR YOUR KIND ATTENTION